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## THE DEDICATION OF THE McDONALD OBSERVATORY

Edited by Dr. OTTO STRUVE

DIRECTOR OF THE YERKES AND McDONALD OBSERVATORIES

THE dedication of the W. J. McDonald Observatory of the University of Texas, on Mount Locke, near Fort Davis, Texas, took place in the afternoon of Friday, May 5. More than 400 invited guests from all parts of the United States, from Canada, Mexico and some European countries were present on the observing floor of the 62-foot dome. The speakers were located on the observing bridge. Dr. Edward Randall, vice-chairman of the Board of Regents of the University of Texas, introduced the speakers.

The session was opened by Mr. C. J. Stilwell, president of the Warner and Swasey Company, who described the activities of his firm in the production of large telescopes and who formally turned over the keys of the dome to Dr. Otto Struve, director of the McDonald and Yerkes Observatories.

In accepting the observatory from the Warner and Swasey Company Dr. Struve spoke as follows:

The purpose of this observatory, in the words of the man whose name it bears, is "the study and promotion of the study of astronomical science." To promote the study of astronomical science means to discover the fundamental laws of nature which govern the structure of the material universe and the changes within it. It means that astronomers must not be passive observers of strange and unexplained phenomena in the cosmos but must be active and intelligent explorers of the vast unknown.

Mr. Stilwell, when I recommended in 1933 to the Board of Regents of the University of Texas that the contract for this observatory be awarded to the Warner and Swasey Company, I knew that your distinguished director of engineering, the late Mr. E. P. Burrell, would be able to meet the exacting specifications which our committee of astronomers had prepared. The telescope was not intended to be just one more expen-

sive gadget to be discarded, ultimately, in the graveyard of scientific instruments. It was to produce answers to a number of specific questions. If it succeeds in this task it will have served its purpose. If it does not succeed, we shall be obliged to regard it as an expensive failure.

There is a story connected with the first attempt to anneal the great mirror disk, after it had been successfully cast at the Corning Glass Works on the last day of 1933. The glass was slightly checked in several places when the annealing oven was removed several months later, and the Corning experts, Dr. Hostetter and Dr. McCauley, immediately offered to melt the glass and to anneal it a second time. During this process of melting, the liquid glass pressed against the firebricks, of which the mold was constructed, and pushed them slightly apart—with the result that we finally got a disk of 82½ inches instead of the contracted disk of 80 inches! I do not guarantee the absolute correctness of this story, but we did get, by some stretching, an 82½-inch disk.

Unfortunately, this is all the stretching our mirror, or for that matter, the truth, will stand. The 82-inch is not a particularly large mirror, and some of our good friends are wasting their time in trying to prove that it will be just as powerful or just as efficient or, anyway, just as good as the Mount Wilson 100-inch. It will be nothing of the sort—as simple geometrical considerations will convince you. I wish we could do some more "stretching," but not even an expert in relativity could stretch the 82-inch mirror to measure 100 inches or to make the half-million dollars available for this project pay for a two-million dollar telescope.

If we can not excel in size we must excel in efficiency. Aperture is important; for some problems it is all-important. Such problems are not within the scope of our observatory. We shall not attempt to extend the geometrical boundaries of the universe of galaxies; this task is taken care of by Dr. Hubble at Mount Wilson. Nor shall we attempt to photograph stars within our own galaxy which are fainter than any hitherto recorded. Dr. Baade is engaged in this type of work with the 100-inch.

What we propose to do is to study intensively the relatively bright stars of our galaxy—as individuals and not only as statistical material. We want to know why it is that all matter in the world is segregated essentially in two forms—stars and nebulae. Why are there no stars which exceed in mass a few hundred times the mass of the sun? Why is it that nearly all stars and nebulae consist of the same chemical elements in roughly the same relative proportions as we find them in the sun? Where and how do the stars generate their stupendous energies of light and heat, and what is the ultimate fate of their radiation?

To answer these and many other similar questions we have made this telescope as efficient and as powerful as we know how for studying the spectra and the brightnesses of the stars and nebulae. We decided to make the telescope relatively short—only 27 feet in focus—so that the images of the stars would be small, even when the air outside is not quiescent. We even built a special spectrograph for the prime focus which effectively converts the telescope from an f/4 instrument to an f/2 instrument. We did this at a sacrifice in limiting faintness of the stars we can observe because we wanted to photograph rapidly hundreds of stars on one plate, instead of spending hours on every single object. There are a billion stars or more, which have never even been looked at and which this telescope will be capable of analyzing and classifying.

We wanted to get a mirror which would be perfectly free of all distortion when used visually or photographically. Corning supplied us with a Pyrex disk which changes little with temperature, and Mr. C. A. R. Lundin has put on it a figure so close to the true mathematical ideal that our experts assure us we have the finest astronomical mirror ever made.

The spectrographic requirements have been constantly in the foreground during the design of the telescope. That we have succeeded in our aim is amply demonstrated by the work of my colleague, Professor Kuiper, during the past six weeks. He has secured some 600 spectrograms of stars never before examined by any astronomer, and has added several brilliant discoveries to the list of his former achievements.

We are indebted to many friends and scientific colleagues for assistance in this project. Perhaps one of the most important features of the 82-inch is the Coudé arrangement for photographing stellar spectra with large prisms or gratings. I need not tell you that this idea was first successfully developed by Dr. Adams at Mount Wilson. We owe another important idea to Dr. Curtis, of Michigan. It was at his enthusiastic insistence that the prime focus and not the Newtonian focus should be used that we scrapped some of our plans—already partly executed—and built a large camera for the prime focus. The telescope drive originated at the McMath Observatory, and to Mr. Robert R. McMath and his collaborators we are deeply indebted for the great help which they gave us when we were designing our drive. My colleagues agree with me that this drive is practically perfect.

It would take too long to even briefly mention all those who have contributed to the success of the McDonald Observatory project. Many of them are here this afternoon.

One hundred years ago—in 1839—two of the world's greatest observatories were opened for research: the Harvard Observatory at Cambridge, Mass., and the Pulkovo Observatory near Leningrad (then Saint

Petersburg), Russia. We are fortunate in having with us here the distinguished director of the Harvard Observatory—Dr. Harlow Shapley. The director of the Pulkovo Observatory is not here—he is a recent victim of one of the most cruel dictatorships of all times. The disturbed international and political conditions of the world to-day are not conducive to quiet research. But the two observatories I have just mentioned have weathered many storms. In accepting this magnificent telescope I venture to hope that the McDonald Observatory is destined to weather the storms of the present and of the future and to become one of the great centers of research where the cultural treasures of the world are preserved and enriched.

A message by President Robert M. Hutchins, of the University of Chicago, who was prevented by illness from attending the dedication, was read by Dean Henry G. Gale, of the Division of the Physical Sciences of the University of Chicago:

This is a great occasion for science and for education. The scientific implications are clear enough. The educational implications are not so obvious, but they are just as important. Two universities are about to demonstrate the value of cooperation on a large scale. We have usually denied the possibility of cooperation. The experience of Texas and Chicago since this observatory was started shows that it is possible and even pleasant. Ever since President Benedict and I first talked about astronomy, the University of Chicago has enjoyed the most cordial relations with the University of Texas. In view of the distance that has separated us and the difficulties inherent in the early days of so vast a project, we can safely say that if we have got along up to now, we shall get along in the future. It is only fair to add that our task has been made easy by the confidence both institutions have had in the distinguished director of the observatory, Professor Struve. Without his unusual combination of energy, tact and scientific knowledge this gathering could not have been held to-day and might never have been held at all. On behalf of the University of Chicago, its faculty, students and trustees, I send the heartiest greetings to the University of Texas and the assembled guests of the observatory. This day will go down in history as one of the brightest in the annals of science and of the universities in America.

Major J. R. Parten, chairman of the Board of Regents of the University of Texas, then spoke for the university:

This is a happy day for Texas. On this day a dream which Texas has long been sharing with its friend and neighbor, Illinois, comes into reality. Texas in general, and the university in particular, can at last call the plant of a modern, powerful observatory their own.

William Johnson McDonald and Harry Yandell Benedict knew and loved the stars. . . . It is because of these two men that the observatory came into being, and that we have reason to be gathered here to-day. In accepting this immensely valuable laboratory for the university we feel that we stand in the light of a day the brightness of which will not soon dim. It is a day made bright by the presence of top-ranking scientists and leading educators, and a day made brighter still by the cherished memory of the two far-seeing Texans who made its sun rise. William Johnson McDonald provided the observatory in quantity of physical plant. Harry Yandell Benedict provided, by his planning and collaboration, the observatory in quality of structure and staff. . . . Our interim president, Mr. John William Calhoun, in 1924, two years before the McDonald bequest became known, put into a statement his own opinions, which were almost precisely those of his predecessor. He wrote: "Among one of the pressing needs of the University of Texas is an astronomical observatory. When the university opened in 1883, it was planned to add astronomy to the curriculum at an early date, but no courses in astronomy were given until 1899; and there is at the present time not even a student observatory on the campus—much less a research observatory with a large telescope such as are possessed by the Universities of California, Wisconsin and Chicago." Dr. Benedict and Mr. Calhoun worked happily with Dr. Hutchins and Dr. Struve to form a basis for the construction and joint operation of the observatory. Texas could by no means have supplied a staff, even had the bequest been greater, to equal that under the present arrangement. The university feels that it is honored and has benefited immeasurably by this association with the University of Chicago. With the staff of the Warner and Swasey Company, the builders of the plant, the University of Texas has enjoyed a most pleasant and satisfactory relationship throughout the performance of the task of design and construction. It is, therefore, a matter of the greatest satisfaction and an occasion of sincerest felicity that the Board of Regents makes for the University of Texas acceptance of the McDonald Observatory.

Dr. J. S. Plaskett, director emeritus of the Dominion Astrophysical Observatory at Victoria, B. C., described the principal features of the new mirror:

The important element of the optical equipment of the McDonald Observatory, which has just been accepted by the director and the chairman of the Board of Regents, is the main concave parabolic mirror having a diameter of 82 inches, a thickness of 12 inches and a focal length of 320 inches. While the telescope

can and will be used with the principal mirror only, it should be stated for the benefit of non-astronomical listeners that the usefulness of the telescope would be seriously limited if auxiliary smaller mirrors, generally called Cassegrains, were not also available.

The purpose of the Cassegrain mirror is to increase the equivalent focal length of the telescope, and consequently the magnifying power, without increasing the length of the telescope tube. Such an increase would entail a large increase in the dimensions of the telescope and the size of the dome and would enormously increase the cost of the observatory. The surface of the Cassegrain mirror is convex of hyperbolic form and it is inserted, about 7 feet below the focus, in the converging cone of star light from the 82-inch mirror. The cone of light is hence made less converging and is reflected back towards the main mirror, in the most frequently used form passing through the central hole and forming an image of the star about a foot below the mirror cell. The Cassegrain mirror works on a similar principle to the rear negative element of a telephoto camera lens, which gives an enlarged image without increase of camera length.

This particular low power Cassegrain mirror, which is 28 inches in diameter, is attached to the central focussing sleeve at the upper end of the telescope tube and increases the equivalent focal length to 92 feet and the magnification 3.5 times. The focus, a foot below the mirror cell, is in the most convenient observing position and can be easily reached from the elevating platform in any position of the telescope. The star images can be observed visually, focussed on a photographic plate or on the slit of a spectrograph. It seems probable that the telescope will be used in this form for more than half the observing time.

The second high power Cassegrain mirror is 21 inches in diameter, is attached in the same position and increases the equivalent focal length to 155 feet and the magnification 5.8 times. The light from this Cassegrain mirror falls upon a plane mirror inclined at 45 degrees, which sends the beam centrally along the declination axis to the center of the polar axis. Here a second plane mirror, also inclined 45 degrees, sends the beam down the hollow polar axis forming the star image below the south end of the axis in a temperature controlled room where a powerful stationary spectrograph can obtain high dispersion spectra of the brighter stars. This is commonly called the Coudé form and the McDonald telescope is the first of this type of mounting with the tube at the side of the polar axis to be adapted for Coudé observations.

These different forms of the telescope all depend on the quality of the fundamental optical surface, the 82-inch parabolic mirror and, if it is inferior, only poor images can be obtained with any form of the telescope no matter how good the Cassegrain mirrors may be. Hence we come to consider the specified subject of these remarks—"Some Features of the New Mirror."

Practically every one knows in these days of automobiles that the penetrating parallel beam from the headlights is produced by a parabolic reflector with the light in the focus. Conversely a parallel beam falling on a parabolic reflector will make a bright spot or image at the focus and this is what occurs in a reflecting telescope when star light shines on the mirror. Although the star can not be less than twenty-five thousand billion miles distant, a figure readily appreciated in these days of swollen national debts, and may be a million miles in diameter, the beam of light falling on the mirror is so nearly parallel that no instrument however sensitive could detect any lack of parallelism.

This parallel beam of star light is reflected back from the mirror surface in a converging pencil to a focus at the top of the tube 320 inches above the mirror and forms there an image of the star. If light behaved as if it were shot off from the star as infinitely small particles in straight lines and if the mirror were perfect and the air perfectly steady, there would be a very minute circular image of the star one one hundred thousandth of an inch in diameter, quite invisible as a sensible disc of light even with the highest power eyepiece that could be used. Whatever the nature of light, and physicists are by no means so positive about it as they were thirty or forty years ago, it is certainly not transmitted according to simple geometrical rules. For this purpose, the formation of images by lenses or mirrors, light behaves as if it were transmitted by wave motion. The parallel pencil of light from the star in the case of a mirror is reflected back in a converging pencil but is also diffracted by the edge of the mirror cell forming a diffraction pattern at the focus. This pattern consists of a bright central disc surrounded by a series of bright and dark rings, although 97 per cent. of the light is concentrated in the central disc. This is sometimes called the spurious disc, as it is not the image of the star but the pattern produced at the image of a point source by the manner in which the light is transmitted.

The size of this diffraction disc depends upon the aperture and focal length of the objective and on the wave-length or color of the light and for visual light and the 82-inch mirror is slightly greater than one five thousandth of an inch, twenty times larger than the geometrical image. It is the size of this spurious disc which limits the resolving power of telescopes, as the images of a double star must be separated by the radius of the spurious disc before one can be sure of duplicity. It will be of interest to compute geometrically, without reference to wave theory or diffraction,

the optical properties of the 82-inch mirror, and to compare the size of the geometrical image with the diffraction disc.

The quantitative tests were made in the optical shop of the Warner and Swasey Company under practically constant temperature conditions and consisted of measures, by means of an artificial star and knife edge, of the radius of curvature of 12 zones, $2\frac{1}{2}$ inches apart, across the usable surface of the mirror. There were 22 individual measures of each of the 12 radii, 11 each by Mr. Lundin and myself, the probable error of the mean being about one thousandth of an inch for the inner zones and only half that for the more convergent outer zones.

A comparison of the measured radii with those computed theoretically from the properties of the parabola showed remarkably small deviations. Translated into departures of the foci of the zones from the mean focus of the 82-inch mirror, the average departure is only one thousandth of an inch, the maximum amount for an inner zone where the effect on the size of the image would be small is only five thousandths of an inch. There is a relatively simple method for changing these small deviations from the focus into departures of the surface of the finished mirror from the true parabolic curve. No part of the 82-inch mirror, nearly 5,000 square inches of glass, is so much as one millionth of an inch, seven tenths of one millionth, to be exact, from the true theoretical form. This is about one thirtieth of a wave-length of visual light, an indication of the perfection of the optical surface. It is usually considered that a deviation of the wave front of a quarter wave, and hence after the reflection a departure of the mirror surface of an eighth wave should give excellent definition. As the departure of the actual surface is only one fourth the allowable amount it should and does give superb definition.

The quality of the 82-inch mirror may be estimated from a different angle, the diameter of the star image geometrically computed from the measured deviations from the focus. Allowing for the outer zones sending more light to the image, the weighted mean diameter of the geometrical image is less than one six thousandth of an inch, 30 per cent. smaller than the spurious diffraction disc, and hence the aberrations will not enlarge the theoretical image. Further, the specifications called for an image not larger than 0.05 mm, two one thousandths of an inch, while the actual mean diameter is only one twelfth this limit. The diameter of a star image photographed with the 82-inch mirror under only average seeing conditions is 0.05 mm, 1.3 seconds of arc, which will undoubtedly be reduced to 1 second or smaller in good seeing conditions. Obviously the dancing about and spreading out of such a large diffusion disc as 0.05 mm would have markedly increased the photographic image and there can be no doubt that the superb quality of the 82-inch mirror will be of enormous advantage, enabling much fainter stars to be photographed and markedly shortening the exposures required for stellar spectra.

Finally, it will be of interest to make numerical comparisons of the magnitude of the aberrations of the 82-inch mirror with those of the Victoria, Delaware and Toronto telescopes, the only large reflectors whose aberrations have been published. The optical quality is expressed by the smallness of the Hartmann criterion "T," which is simply the mean diameter of the confusion circle in terms of the one hundred thousandth of the focal length. In the McDonald mirror "T" is 0.05 or the confusion circle is only one two millionth of the focal length. The criterion "T," the mean diameter of the geometrical image and the magnitude of the aberrations are $2\frac{1}{2}$ times larger in the Victoria mirror, 3 times larger in the Delaware mirror, and 4 times larger in the Toronto mirror. The Cassegrain mirrors of the McDonald telescope have, I believe, an even greater margin of superiority over the others, and are of superfine quality, the photographic images in average seeing being only increased from 1.3 to 1.5 seconds of arc by the addition of a Cassegrain mirror.

There can be no question of the superb quality of the optical equipment of the McDonald Observatory, nor of the accuracy and great convenience in operation of the mounting of the telescope. The University of Texas and the director and staff of the observatory are very fortunate in possessing such unequalled facilities for extending our knowledge of the universe. They were also very fortunate in having a firm like the Warner and Swasey Company undertake the construction of the telescope and observatory building. No other firm has the facilities to make such an instrument, and I know of no other firm who would persevere in the determination to make this the best and most complete telescope possible without regard to the cost. Tribute should be specially paid, in this description of the optical parts, to the remarkable skill of Mr. C. A. R. Lundin, among the foremost of living opticians, who is in charge of the optical department of the company. It was his skill and experience in optical work and his determination to persevere in the figuring until even his exacting standards were fulfilled that was mainly responsible for the magnificent quality of the optical surfaces.

Professor Arthur H. Compton, of the University of Chicago, spoke on "The First of the Sciences," and outlined the close relation between astronomy and physics. This stirring address will doubtless be published elsewhere.

In conclusion, Dr. Homer P. Rainey, president-elect of the University of Texas, spoke as follows:

The opening of this observatory is an event of great significance to the scientific world, and one of just pride for the people of Texas. For astronomers it is an enlargement and a refinement of the instruments of their craft; it opens new possibilities of extending their chart and knowledge of limitless space. For the University of Texas it is another symbol of the rise of the university to a place of prominence in the world of science.

To the appreciation of one man for the glory of the starry universe in which he lived we are indebted for this magnificent instrument. W. J. McDonald, from his youth, had a profound interest in the wonders of nature which he observed round about him. Although we are told that he had a lively and intelligent interest in animal life, he was especially engrossed in botany and astronomy, and as time went on his love for astronomy overshadowed his other scientific interest. His study of the heavens became so consuming that he left all the accumulations of his life's work for the building and equipping of an astronomical observatory. Mr. McDonald wanted it to be an instrument of such size that it would enable astronomers to peer farther into the universe than man had ever been able to do before.

He once humorously remarked to his Negro barber that some day a telescope would be constructed that would enable an astronomer to see the gold-paved streets of the New Jerusalem. While this telescope which he has made possible can not be expected to reveal to us a celestial city with streets of gold and gates of pearl, it will undoubtedly bring within our vision the vastness and glory of a universe yet unknown that will be more inspiring than that one seen by the disciple on the Isle of Patmos. They very reality of the universe which this instrument will reveal will be far more liberating to the human mind and spirit than the mere fruits of imagination, however inspiring they may have been.

Man's knowledge of the stars has always been a central feature of his poetry and his religion. A contemplation of them has always had what Robert Louis Stevenson called "a serene and gladsome influence on the mind." "The greater part of poetry," he said, "is about the stars; and very justly, for they are themselves the most classical of poets." From time immemorial the stars have had a fascination for man's mind far greater, perhaps, than any other part of the universe. Man's thoughts are never so lofty and pure as when he is in some quiet and serene place gazing into the heavens and listening to "the music of the spheres."

Mr. McDonald, therefore, has made far more than a contribution to the advancement of science. He has made possible the enlargement and the uplifting of the soul of man, and this is a gift that surpasses all others.

In our rejoicing over this munificent gift from Mr. McDonald we should not fail to recognize also the splendid part which former President H. Y. Benedict had in the erection of this observatory. He was himself an astronomer and he understood the requirements of an astronomical observatory. He had an exceptional grasp of the entire situation, and it is because of his understanding that the observatory is located in the most advantageous spot in Texas.

There is perhaps no better place in the entire country for an observatory. Texas has long been famed as a land "where the skies are not cloudy all day," and in this particular region there are more cloudless days than in almost any other place. Furthermore, the atmosphere in this region is as clear as any that can be found, which will be a marked advantage in observations. There is also another favorable feature of this "Olympian station." It is far from even "the whispering rumor of a train" or other disturbances, and where, in the evening, the world falls into a dead silence conducive to observation, reflection and contemplation. All these factors combine to make this a most fortunate location for the observatory.

Another unusual feature of this entire enterprise is the fact that for thirty years it is to be operated cooperatively by the University of Texas and the University of Chicago. President Hutchins, who conceived this cooperative relationship, has already spoken of this situation. So far as I know, this relationship is unique and is, I believe, a very fortunate one. This sort of cooperation suggests other similar possibilities. It happened in this case that the University of Texas had the funds for an observatory but did not possess a faculty in astronomy, and a telescope is of very little use without astronomers to operate it. On the other hand, the University of Chicago had an outstanding faculty, but was in need of more and better equipment for observation. Speaking for the University of Texas, I can assure President Hutchins and the trustees of the University of Chicago that we are delighted with this arrangement, and we anticipate many fine values to accrue from it over and above the magnificent scientific research which will be done here. We pledge the University of Chicago our complete cooperation to the end that the finest possible results may be realized through this joint enterprise.

We are here to dedicate this observatory to the most ancient and purest of all the sciences. In doing so, may I express the hope that this observatory will stand as an enduring symbol of the insatiable desire of man to discover the secrets of the universe, and that it may also stand as a symbol of the freedom of man's mind to explore the boundless areas of truth without any restrictions whatsoever.

To these ideals I dedicate the McDonald Observatory in the name of the University of Texas, and now declare it open for research.

The dedication was followed by a symposium, sponsored by the Warner and Swasey Company, on "Galactic and Extragalactic Structure," the program of which was given in SCIENCE for March 3, 1939. The majority of the symposium papers will be published in the *Astrophysical Journal*.

# BIOPHYSICS AND HYDRAULIC ENGINEERING

By Dr. J. F. HERRICK

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How many hydraulic engineers have had their attention attracted to the circulatory system of man and animals? Perhaps it is the most ingenious hydraulic engineering feat in nature. Few investigators have taken a broad glance at the circulatory system from an engineer's point of view.

The purpose of the present paper is to describe some fundamental problems which confront the biophysicist who is interested in the circulatory system. These problems require a thorough understanding of applied fluid mechanics. The hydraulic engineer is better prepared than the average biophysicist to attack such problems.

In the blood vascular system we have a circulatory system in which the average pressure is maintained at a relatively constant value unless an emergency alters it, whereupon a mechanism is called into action which promptly restores or attempts to restore normal conditions. When certain defects develop, the normal pressure becomes inadequate for performing the necessary functions. Under these conditions the system operates at a higher pressure, thus introducing its compensatory mechanisms. The various mechanisms whereby the circulatory system accomplishes its functions of (1) supplying nutritive materials to different parts of the body, (2) eliminating the waste products of catabolism, (3) regulating the pressure, (4) regulating the temperature and (5) distributing hormones and various chemicals to their proper depots, would fascinate any hydraulic engineer.

The particular problems which confront us at the moment and which I wish to describe have to do with pressure and with flow and will be treated separately.

## PRESSURE

*Methods of measurement.* The ideal method for measuring blood pressure is still lacking. True enough, the measurement of the pressure is an everyday affair. The universally used method is an indirect one where pressure is applied in order to cause a complete collapse of the blood vessel. If arterial pressure is being observed, both systolic and diastolic pressures are recorded. These pressures are those which occur simultaneously with certain arbitrary sounds heard over the given artery by means of a stethoscope on releasing the collapsed vessel. I shall not take time to describe the details of the apparatus and the technique used in this (auscultatory) method. The standard method which is used experimentally consists in cannulation of a given blood vessel and proper communication with a suitable manometer.

The ideal method would be one which permits continuous recording of blood pressure—an automatic method, so to speak. The indirect method obviously does not permit continuous observation. The direct method makes constant recording impossible because there is no anticoagulant which keeps blood from clotting for an indefinite period. In addition, the isolation and cannulation required also limit the time of recording.

One might imagine a possible relation between the pressure on the wall of a partially closed blood vessel and the true pressure of the contained blood. If such a relation could be found to be consistent, the pressure on the wall of the vessel might be recorded by using the principle of piezoelectricity. Such a method as this would permit continuous observation of blood pressure.

To put the problem in question form: how would you measure the pressure of a coagulable fluid circulating in a closed elastic system without either direct communication with the fluid or completely collapsing the elastic "pipe"?

*Differential pressure.* Owing to the action of the pump in this circulatory system the pressure varies throughout the cycle of the pump (cardiac cycle). When the pump is contracting, the pressure in the system is maximal and is named systolic pressure. When the pump has finished its contraction and is temporarily in a state of rest, the pressure in the system is minimal and is called diastolic pressure. One may also observe the average pressure throughout the cardiac cycle. As in other hydraulic systems there is a gradual decrease in the average pressure throughout the system from the output to the input sides of the pump. The term pressure-gradient characterizes this well-known variation. However, if one considers the systolic pressure only, an interesting phenomenon presents itself—the systolic pressure in the leg artery (femoral artery) is about 30 to 50 mm of mercury higher than that in the neck artery (common carotid artery) in spite of the fact that the leg artery is much

further away from the pump than the neck artery. This difference in systolic pressure exists even when the body is lying in a horizontal plane. This observation is a well-known fact among those measuring blood pressures. However, no one knows why. Many explanations have been offered, all of which reduce to three basic principles:

(1) A transformation of kinetic energy into pressure energy—a Pitot tube effect. The change of momentum of the moving fluid acting in addition to the lateral pressure causes an increased pressure. Pitot tubes are so constructed as to make use of this effect in measuring velocity of fluids.

(2) A water hammer effect. The more or less abrupt change in velocity that the blood in the femoral artery undergoes gives rise to pressure waves similar to those observed in water pipes. The velocity in the common carotid artery does not change so abruptly.

(3) An effect due entirely to the elastic property of the "pipes" which brings about a higher systolic peak in the femoral than in the carotid artery.

Text-books on applied fluid mechanics indicate that one could distinguish between a Pitot tube effect and a water hammer effect. If the Pitot tube effect exists then the difference in pressure indicated by the Pitot tubes is proportional (approximately) to the square of the velocity of flow. If the effect is due to a water hammer, then the relationship between change in pressure and change in velocity will be linear.

The solution of the problem calls for accurate methods of measuring pressures and velocities of blood. The biophysicist and physiologist can measure pressures very accurately. However, there is not, at present, a method of measuring blood velocity which would be entirely satisfactory for solving this problem.

The physiologists have known about this interesting phenomenon of differential systolic pressures for almost fifty years. A completely satisfactory explanation of the phenomenon has never been attained.

## FLOW

*Methods of measurement.* A direct method of measuring anything is always preferred from the point of view of accuracy. However, in the measurement of blood flow an indirect method is preferred if one wishes to maintain normal physiologic conditions in studying the characteristics of flow. The peripheral circulatory system is so close to the condition of turbulence that any interference with it may produce turbulence, especially on the arterial side. A continuous indirect method is the ideal method since it preserves normal physiologic conditions, providing the indirect method does not require operative procedures which alter the normal conditions. When one considers the physiologic variation, he realizes that to develop an absolutely accurate method of measuring blood flow would be a waste of time even if it were possible. One learns in his study of physics, as well as of other sciences interested in measurement, that the accuracy of the method should conform to the conditions of the problem. It is as ridiculous to have too accurate a method as it is to have too inaccurate a method in certain studies. One's common sense must be used in all cases.

In order to use certain indirect methods properly, a knowledge of the character of flow is absolutely essential. The method may be very reliable as long as the flow is laminar or streamline but may be 100 or 200 per cent. inaccurate when the flow becomes turbulent.

To describe the various methods of measuring blood flow developed since the time of Volkmann would require the space of a fair-sized book. It is sufficient to say that most methods consist in the application of well-known physical principles such as the Venturi meter, rate of cooling, change of electric resistance with change of temperature, electromagnetic induction, the hydrometric pendulum and other devices.

*Character of flow.* The method of measuring flow which I have used for several years is dependent on the type of flow. I am much interested in the question. Is the blood flowing in a given vessel streamline or turbulent?

This paper is written primarily with the hope that the hydraulic engineer will be able to offer suggestions for answering the question or better yet that he will want to take an active part in the study of this interesting problem.

So far as I know, two methods are available for answering this question, a theoretical method and a practical one.

*Theoretical.* "As has long been known from the classical researches of Osborne Reynolds and others, the steady isothermal flow of a fluid through a long straight pipe may occur by one of several mechanisms. When the dimensionless Reynolds number $\frac{DV\rho}{\mu}$ is sufficiently small, the individual particles of fluid flow in straight lines parallel to the axis of the pipe, without appreciable radial component as shown. . . This type of motion is variously described as streamline, straight-line, viscous and laminar. At sufficiently high values of Re, the motion is said to be turbulent, because of the presence of innumerable eddies or vortices present in the central portion of the pipe, as indicated. . . ."[1]

In the preceding quotation Re stands for Reynolds number, which is calculated from the formula $\frac{DV\rho}{\mu}$, where

[1] W. H. McAdams, "Heat Transmission," pp. 99–100. New York, McGraw-Hill Book Co., Inc., 1933.

$D$ = diameter (inside) of pipe
$V$ = average velocity
$\rho$ = density
$\mu$ = viscosity

One can calculate the Reynolds number for blood from the above formula and determine whether the flow is in the streamline or turbulent range. According to such calculations for, say, the femoral artery of a dog, the flow is below the critical value for turbulence. However, I feel that it may, at times, become turbulent.

*Practical.* One may make an exact model of the hydraulic system in question and directly observe the nature of flow by introducing a contrasting color to the fluid at the desired location. This would be rather difficult to do for the problem in question. According to Franklin[2] and others nature offers conditions for the direct observation of the character of blood flow in certain veins. The blood flowing into the abdominal vena cava from the reproductive organs of certain animals is like arterial blood in color and serves as an excellent contrast to the venous blood already present in this vein. According to observations the arterial-like blood flowing into the vena cava at this site continues in its own channel without mixing with the blood already present. This indicates a streamline type of flow. The vein has a thin wall so that the contrasting color may be easily observed. The artery is not so transparent.

Artificial circulatory systems have been made and have proved useful in the perfusion of various organs with blood. I have observed that small constrictions in such systems give rise to turbulent flow. The degree of turbulence produced experimentally is dependent on the type of constriction. Blood vessels *in situ* may have such constrictions under certain conditions, for example, arteriosclerosis and coarctation.

It would be helpful to know exactly the nature of the flow of blood in any given blood vessel at any time. The character of the flow in the great vessels near the heart as well as that in the coronary vessels would be particularly interesting. Attempts have been made to study this problem in acute experiments where a general anesthetic, artificial respiration and anticoagulants are required. All these alter the normal conditions profoundly, so that one can not say the results of the study are maintained in the normal intact animal.

The hydraulic engineer usually works with fairly homogeneous fluids flowing in rigid pipes, so that a problem in which blood, a heterogeneous fluid, circulates in an elastic closed system might present new difficulties.

[2] K. J. Franklin, "Respiration and the Venous Return in Mammals." In "A Monograph on Veins," pp. 236–267. Springfield, Charles C Thomas, 1937.

# OBITUARY

## RECENT DEATHS AND MEMORIALS

Dr. Charles Horace Mayo, emeritus professor of surgery in the Medical School of the University of Minnesota and in the Graduate School of the Mayo Foundation; founder, with his brother, Dr. William James Mayo, of the Mayo Clinic at Rochester, Minn., died on May 26 in his seventy-fourth year.

Dr. Witmer Stone, emeritus director of the Academy of Natural Sciences of Philadelphia and a member of its staff since 1891 as conservator of ornithology and curator of vertebrates, died on May 23 in his seventy-third year.

Arthur E. Wells, professor of metallurgy at Harvard University from 1926 to 1931, director of the American Cyanamid Company of New York, died on May 24. He was fifty-five years old.

Dr. J. Edmund Woodman, professor emeritus of geology at New York University, died on May 19 at the age of sixty-five years.

William H. Kavanaugh, for twenty-three years professor of experimental engineering at the Towne Scientific School of the University of Pennsylvania, died on May 6 in his sixty-sixth year.

Frank W. Durkee, since 1907 head of the department of chemistry at Tufts College, died on May 21 at the age of seventy-seven years.

Professor William L. Hunter, head of the department of industrial arts at the Iowa State College, died on May 23. Mr. Hunter had been a member of the faculty of the Iowa State College since 1927, having previously taught at the State University of Iowa and at the Bradley Polytechnic Institute.

Dr. Maurice Brodie, laboratory director of Providence Hospital at Detroit, Mich., for the last two years, died on May 9 at the age of thirty-six years.

Sir Frank Dyson, from 1910 to 1933 Astronomer Royal of England, previously from 1905 to 1910 Astronomer Royal of Scotland, died while on a voyage from Australia to South Africa on May 25. He was seventy-one years old.

Dr. Yojiro Wakiya, the Japanese ichthyologist, was killed by an electric car near Tokyo, on April 21, at the age of sixty-seven years. He was known particularly for his studies of the Carangidae, Salangidae and Salmonidae of the Japanese Empire, but also published investigations on many other groups of fishes and on oysters. For many years he was director of the fisheries institute at Fusan, Chosen, which he de-

veloped into a leading center of ichthyological and fisheries research.

A CORRESPONDENT writes: "It is with deep regret that we record the untimely death of Dr. I. C. Wen, which occurred in the Peiping Medical College Hospital on Monday morning, April 17, after a prolonged illness. Dr. Wen was born on October 16, 1899, a native of Hupeh. He graduated from Tsing Hua College in 1922. Subsequently he took his Ph.B. in 1924 and Ph.D. in 1927 at the University of Chicago. He became a laboratory assistant in neurology in 1926–1927 at the University of Chicago and a Rockefeller Foundation fellow in anatomy in the department of anatomy at the Johns Hopkins Medical School in 1927–29. Dr. Wen was a member of Sigma Xi. Upon his return to China, Dr. Wen joined the Peiping Union Medical College in 1929, first as assistant in anatomy and then associate in 1931 and assistant professor of anatomy from 1934 until his death. Dr. Wen was a brilliant student in the fields of embryology and neurology."

A PLAQUE was unveiled recently at the Ohio State University in honor of Dr. John A. Bownocker, who died on November 2, 1928. At the dedication services Dr. Charles Foulk, of the department of chemistry, and Dr. Wilber Stout, successor to Dr. Bownocker as state geologist, were the principal speakers. Dr. J. Ernest Carman, of the department of geology, formally presented the plaque to the university. It was accepted by Acting President William McPherson. The tablet, the work of Professor Erwin F. Frey, of the department of fine arts, carries this inscription: "John Adams Bownocker, 1865–1928, BSC 1889, DSC 1897, Ohio State University, Professor of Geology Ohio State University 1898–1928, State Geologist Geological Survey of Ohio 1906–1928. The consuming interests of his life were his native state of Ohio, its geology and its university. He gave to them 30 years of devoted service as teacher and geologist. To Ohio State University he bequeathed his entire estate as an endowment for the work of the department of geology. To his students and his colleagues he left the memory of a rugged unswerving character, rough hewn like the rocks of his own geology."

# SCIENTIFIC EVENTS

## THE LAKE LABORATORY OF THE OHIO STATE UNIVERSITY

THE Lake Laboratory of the Ohio State University on Gibraltar Island near Put-in-Bay has now a year-around program, with continuous study of problems important to the Lake Erie fishing industries. Formerly the laboratory was open only in the summer for courses in advanced biology. Dr. Thomas H. Langlois is director of the laboratory, which has a special staff of instructors and lecturers.

The laboratory serves as headquarters for administration of the fisheries of Ohio, with Dr. Langlois as chief of the Bureau of Fish Management and Propagation of the Ohio Division of Conservation. The operation of twelve inland fish farms is directed from there, fish management agents from eleven districts report to Dr. Langlois, and commercial fishermen make reports of their catches to the laboratory.

Studies of the trends of the fisheries and the success of the fishermen thus are combined with studies of the life-histories of important species, to the end that the laboratory "may discover the factors limiting the abundance of important species of fish and point the way toward an effective conservation program."

Three quarters of the year are devoted to this phase of its work. In the summer the laboratory turns its attention to courses for students in advanced biology. Provision has been made this summer for living quarters for couples and small families, making it possible for students to take their families with them to the lake.

The staff, in addition to Dr. Langlois, includes Dr. Charles F. Walker and Dr. David C. Chandler, who work at the laboratory all the year. Several other members of the faculty of the Ohio State University will work there during the summer. Dr. Ralph V. Bangham, Wooster College; Dr. William F. Hahnert, the Ohio Wesleyan University, Delaware; Dr. Bertil G. Anderson and Dr. Earl L. Core, both of Western Reserve University, Cleveland, will also join the staff of the laboratory. There will be week-end lectures on the bird-life of the lake regions.

Expansion of the program of the lake laboratory has come as a result of an agreement completed last year between the university and the Ohio Division of Conservation, whereby the laboratory assumes responsibility for the division's fisheries research program. In return the conservation division has helped to provide new living quarters for faculty and students, and conservation hatcheries have been made available to the laboratory.

## THE BATTELLE MEMORIAL INSTITUTE

CONTRACTS have been let by the Battelle Memorial Institute, Columbus, Ohio, for the construction of a new research laboratory to take care of the expanding volume of industrial research.

Clyde E. Williams, director of the laboratory, points

out that research expenditures by industry are growing and that the increased laboratory and office space at Battelle have been made necessary by the growing research activity in metallurgy, fuels, ceramics and chemistry.

The new construction consists of a wing extending from the end of the present main building that will provide approximately 50,000 square feet of space on five floors. In this will be chemical and metallurgical laboratories, photographic and metallographic departments, physics laboratories and a large industrial laboratory.

Provision is being made for the relocation and expansion of the mechanical testing laboratory. A new 200,000-pound tensile testing machine is to be purchased to keep pace with developments in the field of metals. Constant temperature and controlled humidity rooms will be provided for chemical and metallurgical studies. The auditorium is being enlarged to increase its seating capacity and additional administrative office space will be available on the ground floor. The research laboratory space in the main building will be practically doubled.

This is the second time in the short history of the institute that space requirements have led to new construction. Less than two years ago a four-story building housing an experimental foundry and ore-dressing and coal-preparation laboratories was completed and put into service. The main building itself was occupied and work began in the latter part of 1929. The staff now numbers about 180.

The Battelle Institute was established and endowed by the wills of Gordon Battelle and his mother, Annie Norton Battelle, of Columbus, to encourage and conduct industrial research. It carries on fundamental and applied research in ferrous and non-ferrous metallurgy, ceramics, physics, organic and inorganic chemistry, fuels, coal preparation and utilization, ore-dressing and materials concentration. Work is done both with its own funds and for industrial sponsors.

The new wing will be of concrete and brick construction, conforming with the present main building. It is to be 60 feet by 150 feet in plan, with five full floors and a basement extension below ground level. The addition will convert the present L-shaped structure into a U, with the new wing some 30 feet longer than the old. Construction will begin at once, and it is expected that the new wing will be ready for use by the first of next year.

## THE FOOD TECHNOLOGY CONFERENCE AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The second Food Technology Conference will be held at the Massachusetts Institute of Technology at Cambridge from June 28 to July 1 under the auspices of the Division of Food Technology and Industrial Biology.

Like its predecessor this conference will deal with the broad aspects of the subject, but special attention will be directed to quality control, food packaging technology, food engineering and refrigeration. Consideration of the specific relation of trained food technologists to the food industries will be given special attention. In addition to members of the institute authorities in food industries and food research laboratories of the United States, Canada and possibly from other countries will be included among the speakers.

The opening session will be one of two particularly devoted to quality control. Sessions will follow relating to the engineering aspects of food technology; a joint session with the American Institute of Baking Engineers on recent developments in baking and associated food industries; a symposium on food packaging technology covering recent developments in the packing of foods in tin, glass, transparent films and rubber latex; and a symposium on Foods and Refrigeration in cooperation with the American Society of Refrigerating Engineers.

Among the guest speakers who are expected to make keynote addresses are Clarence Francis, president of General Foods; Dr. H. A. Baker, president of the American Can Company; President Karl T. Compton, of the Massachusetts Institute of Technology; J. L. Kraft, president of the Kraft-Phenix Company; Dr. O. E. Baker, of the U. S. Department of Agriculture; Dr. L. V. Burton, editor of *Food Industries,* and Professor W. V. Cruess, of the University of California.

A diversified program of entertainment is planned, which will include special luncheons, a barbecue held at the Dewey and Almy plant, an evening at the celebrated Boston Symphony "pop concert" and a banquet at the New Ocean House on the seashore at Swampscott, which will conclude the program of Friday. There will probably be a Saturday morning program, following which ample time will be left free for the proposed organization of an association of food technologists.

The present indications are that the attendance at the conference will be as large as in 1937 when over 600 were registered. Dormitory facilities for those attending the conference will be available in the Senior House of the Massachusetts Institute of Technology at a cost of $1.00 per night. This year there will be a registration fee of $2.50 for all in attendance. Applications for registration cards should be made in advance to Professor B. E. Proctor, Massachusetts Institute of Technology, Cambridge, Mass.

## THE STANFORD UNIVERSITY MEETING OF THE PACIFIC DIVISION OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE twenty-third annual meeting of the Pacific Division of the American Association for the Advancement of Science will be held this year at Stanford University from June 26 to July 1. Sixteen scientific organizations on the Pacific Coast are participating actively by holding scheduled sessions throughout the week; among them are the astronomers, botanists, chemists, ecologists, economic entomologists, ichthyologists and herpetologists, geographers, meteorologists, naturalists, physicists, plant pathologists, plant physiologists, the Society for Experimental Biology and Medicine and the Western Society of Soil Science. Members of associated societies not formally participating have been invited to take part by attending or presenting papers at the scheduled sessions.

The general sessions will open on Tuesday morning, June 27, with a symposium on "Radiation and Life." This will include an address by Dr. W. V. Houston, of the California Institute of Technology, on "Radiation"; "Radioactive Elements as Tracers in Metabolic Studies," by Dr. John H. Lawrence, of the University of California; "Radiation and the Hereditary Mechanism," by Dr. M. Delbruck, of the California Institute of Technology, and "Medical Applications," by Professor Robert R. Newell, of the Stanford University Medical School.

An afternoon session on "Reviews of Current Research" is next on the program. Professor J. W. McBain, of Stanford University, will speak on "Recent Advances in Colloid Chemistry." An address by Professor A. R. Davis, of the University of California, will follow on the subject of "Mineral Metabolism in Plants." Professor Henry Borsook, of the California Institute of Technology, will speak on "Biological Oxidations and Reductions," and Dr. J. W. Macfarlane, of the University of California, will discuss "Research on Personality Development."

A general reception for members and guests of the division and its associated societies will follow this meeting. There will also be three evening addresses during the week. The first, on Tuesday, June 27, will be given by Professor S. J. Holmes, president of the Pacific Division, American Association for the Advancement of Science, and will deal with "Darwinian Ethics and Its Practical Applications." On Wednesday evening Professor V. Gordon Childe, of the University of Edinburgh, will give an illustrated lecture on "The Neolithic Economy in Northwestern Europe," and on Thursday evening Professor J. D. Bernal, of the University of London, will speak on "The Structure of Protein Molecules."

Among the numerous symposia organized by the participating societies, mention might be made of the following: "Dams and the Problem of Migratory Fishes," "Recent Contributions of Botany and Ecology to Society," a symposium on the teaching of plant pathology, "Availability of Nutrients in Soils to Plants," "Translocation of Solutes in Plants," "Growth," "Native Plants of Western North America Offering Exceptional Material for Botanical Research," "New Ultra-high-frequency Apparatus" and "Methods and Results of X-ray Structure Determination." The last-mentioned will include J. D. Bernal, M. L. Huggins, H. Mark, O. L. Sponsler and Dorothy M. Wrinch as speakers.

The meeting of the Pacific Division will be followed by a symposium commemorating the enunciation of the cell theory (July 1 to 5), and by the Sixteenth National Colloid Symposium (July 6 to 8). Both will be held at Stanford University.

J. MURRAY LUCK,
*Secretary*

## THE ELECTION OF FOREIGN MEMBERS OF THE ROYAL SOCIETY

AT a recent meeting of the Royal Society the following were elected to foreign membership in the society:

Professor Walter Bradford Cannon, professor of physiology in Harvard Medical School. Distinguished for (a) his x-ray investigations of the movements of the alimentary canal; (b) his analysis of the mechanism and conditions of excitation of the suprarenal gland and (c) his work on the chemical transmission of impulses in peripheral nerves as shown by the sympathetic system.

Professor Herbert Freundlich, University of Minnesota. Distinguished for his researches in colloid chemistry and colloid physics.

Professor George Von Hevesy, research professor in the Institute of Theoretical Physics, Carlsberg Laboratory, Copenhagen. Distinguished for (a) his work in experimental chemical physics, particularly the use, for the solution of biological and chemical problems, of radioactive and isotopic substances as indicators; (b) for his discovery of hafnium and (c) for his geochemical researches and for his work on isotopes and their separation.

# SCIENTIFIC NOTES AND NEWS

FOREIGN members of the Linnean Society of London have been elected as follows: Dr. William King Gregory, curator of comparative anatomy and ichthyology of the American Museum of Natural History and professor of paleontology at Columbia University; Dr. Alfred Rehder, curator of the Herbarium, Arnold

Arboretum, and associate professor of dendrology at Harvard University; Dr. William Albert Setchell, emeritus professor of botany at the University of California; Professor Alfred Ernst, director of the Institute of General Botany of the University of Zurich, and Dr. William Marins Docters van Leeuwen, formerly director of the Botanic Gardens, Buitenzorg.

Professor Eliot Blackwelder, of Stanford University, has been nominated by the council for president of the Geological Society of America, and Professor Douglas Johnson, of Columbia University, has been nominated first vice-president.

Dr. Elmer D. Merrill, Arnold professor of botany and administrator of botanical collections of Harvard University and director of the Arnold Arboretum, has been appointed by the organizing committee of the seventh International Botanical Congress, to be held in Stockholm in 1940, as one of the presidents of the section of taxonomy and nomenclature and as president of the subsection for nomenclature. He served in similar capacities at Cambridge in 1930 and at Amsterdam in 1935.

Dr. Robert Cushman Murphy, of the American Museum of Natural History, has been elected an honorary member of the Royal Hungarian Institute of Ornithology.

Among honorary degrees to be conferred at the annual commencement exercises of Temple University on June 15 will be the doctorate of humane letters on Dr. Victor George Heiser, who retired in 1934 as associate director of the International Health Division of the Rockefeller Foundation.

The Herty Medal for 1939 has been presented by the department of chemistry of the Georgia State College for Women at Milledgeville, Ga., to Frank K. Cameron, of the University of North Carolina, in recognition of his research on cellulose in cotton.

Dr. George Granger Brown, professor of chemical engineering at the University of Michigan, received on May 16, in recognition of his work on thermodynamics and distillation, the 1939 William H. Walker Medal presented at the Akron, Ohio, meeting by the American Institute of Chemical Engineers. The award is made annually for "outstanding articles published by the institute during three years prior to the award."

At the annual meeting of the Board of Trustees of *Biological Abstracts*, held in Washington on April 25, the following officers were elected: Dr. George W. Hunter, III, *president;* Dr. Anton J. Carlson, *vice-president;* Dr. Alden B. Dawson, *treasurer;* Dr. Conway Zirkle, *secretary*. The executive committee for the current year consists of Dr. George W. Hunter, III, *chairman;* Colonel Arthur Parker Hitchens and Dr. Alden B. Dawson.

Dr. William W. Hutchinson, of Los Angeles, was named at St. Louis president-elect of the Associated Anesthetists of the United States and Canada. In elections of two associated organizations, Dr. Hugh Cunningham, of Milwaukee, was named president-elect of the Mid-western Association of Anesthetists, and Dr. R. Douglas Sanders, of Louisville, president-elect of the Southern Association of Anesthetists.

A dinner in honor of Professor Francis Ramaley, who retires this year after forty-one years as head of the department of biology of the University of Colorado, was given on April 22. Some seventy former and present members of the staff and graduate students were present. Professor Aven Nelson spoke on his reminiscences of early botanical study in the Rocky Mountain region. Professor Ramaley was presented with a dissecting binocular microscope and a volume of congratulatory letters.

Professor W. L. Blizzard, since 1919 head of the department of animal husbandry of the University of Oklahoma, has been appointed dean of the School of Agriculture and director of the Experiment Station.

Professor Henry P. Rusk, head of the department of animal husbandry since 1923 and a member of the staff for twenty-nine years, has been appointed dean of the College of Agriculture of the University of Illinois, director of the Agricultural Experiment Station and director of the Extension Service in Agriculture and Home Economics. He will succeed Dr. J. C. Blair, who will retire on September 1.

Dr. J. D. Cockcroft, lecturer in physics in the University of Cambridge and fellow of St. John's College, has been elected Jacksonian professor of natural philosophy.

Dr. Dorothy Garrod, daughter of the late Sir Archibald Garrod, Regius professor of medicine at the University of Oxford, has been elected to the Disney professorship of archeology at the University of Cambridge in succession to Dr. E. H. Minns, who retires in October. Dr. Garrod is director of studies in archeology and anthropology at Newnham College, and is known for her excavations in the Near East and at Gibraltar.

Dr. John H. Parker, professor of agronomy at the Kansas State College, Manhattan, has resigned to become director of the Kansas Wheat Improvement Association, with headquarters in Manhattan. He has been succeeded at the college by L. P. Reitz, of the U. S. Department of Agriculture.

Dr. Leonard A. Maynard, professor of animal nutrition, and Dr. John K. Loosli have been placed in

charge of a five-year project on the nutrition of animals, recently inaugurated at Cornell University by the United States Biological Survey. The initial object of the project is to determine proper foods for fox and mink, as an aid to fur farmers.

DR. HUGH S. CUMMING, surgeon-general of the United States from 1920 to 1936, returned on May 24 on the liner *Manhattan*, of the United States Lines, after attending, as medical delegate, assemblies in Geneva and Paris.

DR. T. G. YUNCKER, professor of botany at DePauw University, is spending next year in the south Pacific area making collections and studying the flora of southeastern Polynesia on a Yale-Bishop Museum fellowship. He sails in July for Honolulu and later will go to the Tongan archipelago, where he plans to spend several months.

DR. FRANK E. EGLER, assistant professor of ecology and taxonomy at the New York State College of Forestry, is sailing on June 3 from New York City on the *S. S. Nerissa* for Martinique. He will spend the summer on botanical investigations in the French Antilles, with the cooperation of Dr. Henri Stehle, director of the Tivoli Experiment Station. The work will include an ecological reconnaissance of the vegetation in semi-arid regions with reference to soil, water and forage conservation. These studies are in line with the Hawaiian investigations of Dr. Egler, who was Yale University-Bishop Museum fellow in 1936–1937.

DR. A. M. CHICKERING, professor of biology and chairman of the division of science and mathematics in Albion College, Michigan, has been on leave studying his collections of Central American spiders at the Museum of Comparative Zoology, Harvard University. A few weeks also were spent in the Osborn Zoological Laboratory, Yale University, as guest of the laboratory and of Professor Alexander Petrunkevitch. On June 14, with his son as assistant, he expects to sail for work on spiders in Panama. Dr. G. W. Prescott, of Albion College, with assistants, will join him later in the summer, primarily for an investigation of the algae of the Panama Canal and associated waters.

DR. OSKAR KRAUS, director of the Brentano Institute of Prague, has been appointed Gifford lecturer in natural theology at the University of Edinburgh for the academic year 1940–41.

FORMER PRESIDENT HERBERT HOOVER, honorary member of the American Society of Mechanical Engineers, will give an address before the society at the Golden Gate International Exposition, on Engineers' Day, July 13. He will discuss the contributions that have been made by engineering to human welfare. Dr. Rodolfo E. Ballester, director of the Irrigation Department of Argentina, S. A., will give the Calvin W. Rice lecture. He will speak on hydraulics and how engineers of the United States may better cooperate with those of South America. He is expected to arrive in New York on June 26.

DR. A. J. CARLSON, professor of physiology at the University of Chicago Medical School, gave an address on "Science and the Common Life" at the dedication of the new building of the May Institute for Medical Research of the Jewish Hospital in Cincinnati.

DR. LEWIS JOHN STADLER, principal geneticist of the Office of Cereal Crops and Diseases of the Bureau of Plant Industry, gave the ninth series of Frank Azor Spragg Memorial Lectures at the Michigan State College on May 16, 17, 18 and 19. These lectures were established by the Michigan State Board of Agriculture in 1930 as a memorial of the contributions to Michigan agriculture by Frank Azor Spragg, plant breeder at the Michigan Station from 1906 to 1924.

IN the symposium on "The Cell and Protoplasm" to be given at Stanford University on July 1, the program of which was printed in the issue of SCIENCE for May 19, the paper entitled "The Cell Wall and Protoplasm" is to be given by I. W. Bailey, of Harvard University, not by L. H. Bailey.

THE Royal Swedish Academy of Science is this year celebrating the two hundredth anniversary of its founding on June 2, 1739.

THE American Malacological Union will hold its ninth annual meeting in the Royal Ontario Museum of Zoology, Toronto, from June 20 to 23.

THE forty-first annual meeting of the Medical Library Association will be held on June 27, 28 and 29 at the Academy of Medicine of Northern New Jersey, Newark. The program will include addresses, discussions and demonstrations on library procedure, medical history and literature. This association consists of about two hundred and fifty of the medical libraries of the United States and Canada, together with their librarians and a group of supporting members, who are chiefly physicians interested in medical literature and libraries. The officers of the association are as follows: *President,* James F. Ballard, Boston; *Vice-president,* Dr. George R. Minot, Boston; *Secretary,* Miss Janet Doe, New York; *Treasurer,* Miss Louise D. C. King, Baltimore, and *Chairman of Executive Committee,* Miss Marjorie J. Darrach, Detroit. Every one is invited to attend who is interested in a wider knowledge of medical literature and in the development of medical libraries.

THE British Association for the Advancement of Science held the first public meeting in London of the

new division for the Social and International Relations of Science at the Royal Institution on May 25. Professor Ernest Barker, professor of political science at the University of Cambridge, and Sir Daniel Hall, formerly chief scientific adviser to the Ministry of Agriculture, were the principal speakers. Sir Richard Gregory was in the chair. The object of the meeting was to show how science and society are "out of gear," and to explain the nature of the task that the division has undertaken in trying to bring about an adjustment. Professor Barker spoke on "The Impacts of Science on Society," and Sir Daniel Hall on the application of science to agriculture. Sir Richard Gregory dealt with the work of the division. The meeting was intended for workers in every branch of science with a view to securing their interest and cooperation in the work of the division, which at present is concerned with questions of nutrition, population, social psychology, the organization of science and the international relations of science. A committee has also been appointed to report on the world sources of raw materials.

The Department of Agriculture awarded an $842,000 contract on May 25 for construction of an eastern regional research laboratory at Wyndmoor, Pa. The contract calls for completion in four hundred days of the entire administration unit, together with nine sections of the chemical laboratory wing, and the entire service building and power plant.

The cornerstone of Fuld Hall of the Institute for Advanced Study at Princeton was laid on May 22 by Miss Lavinia Bamberger, sister of Louis Bamberger, co-founder of the institute. The building is being erected at a cost of $500,000, on a 400-acre tract of land on the southwest outskirts of the Borough of Princeton. The hall is expected to be completed in time for the opening of the fall term. Fuld Hall, named in honor of the late Felix Fuld, is being constructed of red brick in colonial design. When completed it will contain separate studies for each faculty member and student of the institute's three units, besides administration quarters, seminar rooms, lounges and a library.

# DISCUSSION

## BIRTH PAINS OF THE ASSOCIATION

One hundred years ago, in 1839, *The Family Magazine, or Monthly Abstract of General Knowledge* published the following article on the organization of a national scientific society. This magazine was published at Boston by J. S. Redfield, first president of the American Association for the Advancement of Science.

I am indebted to Mr. Joseph A. Sadony, Valley of the Pines, Montague, Mich., for the reference and the following quotation. Such words from leaders among our predecessors of a century ago emphasize the enormous changes that have taken place within three generations.

F. R. Moulton,
*Permanent Secretary*

### NATIONAL SCIENTIFICK ASSOCIATION

When the proposition was made, in February last, to the Massachusetts Medical Society, to open a correspondence with other similar bodies, upon the expediency of organizing a national association for the advancement of the physical sciences, there were gentlemen who expressed an opinion that the movement was premature; and further, it was maintained that no very marked discoveries or brilliant achievements had resulted from such combinations of the learned in other countries. On the other hand, all important and really striking and meritorious advances in science, literature and the arts, were made, it was contended, in the quiet of the closet, by those who hardly identified themselves with the busy world. In fine, nothing of importance to the promotion of science had emanated from these modern much-talked-of-compacts of the old world.

With a variety of theories and individual presentiments, none of which, by others, were considered of much consequence, it is sufficient to say that the project was rather coldly received, and ultimately quashed in embryo by the committee to whom the matter was referred by consideration. Now it is morally certain that by a little exertion, a successful plan of operation might, by this time, have been devised, and a vigorous co-operation manifested in every state in the union.

The idea that we were too young, as a people, for such a vast undertaking, was preposterous in the extreme. Whoever reflects upon the character of the present age, the spirit that animates all ranks of inhabitants, the impulse given the nation by transatlantick influences, in all departments of life, can not resist the conviction that the same system of perseverance which distinguishes the efforts of civilized man in Europe, will and must be felt in America. With a vast territory, the resources of which are almost incalculable, a consolidation of interests in science, of all the available forces, from the college to the cottage, can alone develop the geological and physical constitution, capabilities and concealed wonders, of this great portion of the habitable globe.

As predicted, another effort is making to rally the learned of the United States around one common centre, to unite in an enterprise which must gratify every friend of science; and of its final success, there is scarcely a remaining doubt, notwithstanding the objections which have heretofore been urged against a scheme so praiseworthy and meritorious. A meeting was held at the hall

of the American Academy in this city, a short time since, at which Governour Everett presided, to discuss the propriety of the measure, and a committee was appointed to consult with the Philosophical Society of Philadelphia; and thus the lines are laid, which we fervently hope will speedily eventuate in the establishment of a national association for the promotion of the physical sciences—founded in motives as noble and acceptable to the world as were those which originated the association now existing in England, the organization of which constitutes a new era in the history of that nation. It is to be deplored that our Medical Society did not secure to itself, when the opportunity presented, the honour of having carried into effect this excellent proposition, which might have been done with most perfect ease, and consistently, too, with its character of a scientifick body. For it is evident that practical and enlightened physicians, in all countries, are among the most zealous cultivators of learning and science; and we noticed, upon the occasion alluded to, that of the twenty-seven individuals present, thirteen were members of the Massachusetts Medical Society.

## PRELIMINARY ANNOUNCEMENT OF THE GOOSE LAKE, CALIFORNIA, METEORITE

THROUGH the cooperation of several of the officers and the fellows of the Society for Research on Meteorites, namely, Dr. and Mrs. H. H. Nininger, of the Colorado Museum of Natural History and the American Meteorite Laboratory, Denver, Professor Earle G. Linsley, of the Chabot Observatory and Mills College, Oakland, Calif., Dr. Robert W. Webb, of the Department of Geology of the University of California, Los Angeles, and the writer, the largest meteorite discovered up to date in the state of California and probably the fifth largest known to have fallen in the United States, has recently been identified and has just been recovered. The meteorite, which is an iron or siderite, was found on October 13, 1938, by Messrs. Joseph Secco, Clarence A. Schmidt and Ira Iverson, of Oakland, Calif., while hunting deer at a place in northern Modoc County, about two miles west of the western shore of Goose Lake and 1¼ miles south of the California-Oregon state line (coordinates approximately, longitude W. 120° 32′.5, latitude N. 41° 58′.6). The meteorite was removed from the place of fall on May 3 and 4, 1939, by a party of which the aforementioned scientists were members. Since the specimen was located in the Modoc National Forest, it is the property of the Smithsonian Institution and the United States National Museum; however, through the kindness of Dr. Alexander Wetmore, the assistant secretary of the Smithsonian Institution, the body will be on exhibition at the Golden Gate International Exposition in San Francisco until the conclusion of the fair.

The over-all dimensions of the meteorite, which is a very irregular mass, deeply pitted, perforated and unoriented, and which resembles in shape nothing more than a gigantic molar tooth, are 3 feet 10 inches × 2 feet 4½ inches × 1 foot 8 inches. The measured weight is 2,573 pounds. Etching the polished surface of a small fragment with dilute nitric acid revealed the characteristic Widmanstätten figures, which indicate that the specimen is a medium octahedrite. The more weathered parts of the meteorite are maroon, while the portions which have lain near or in contact with the soil are cinnamon-brown or rusty. Because all the original fusion crust is missing, we conclude that the fall occurred probably many years ago. The meteorite lay in the center of an almost circular, saucer-like depression or "crater," about five feet in diameter and one foot deep. This formation was the only visible evidence, if evidence it was, of the impact of the body with the ground. As no postoffice is situated within a radius of several miles of the spot where the meteorite was discovered, and it was not near any well-known geographical feature other than Goose Lake, it shall be called the Goose Lake, Modoc County, Calif., meteorite.

FREDERICK C. LEONARD

UNIVERSITY OF CALIFORNIA,
LOS ANGELES

## A PARASITE OF THE PUERTO RICAN MOLE-CRICKET

To the record of successful establishments in Puerto Rico of predators attacking insect pests, such as that of the giant Surinam toad, *Bufo marinus* L., largely feeding on native species of May beetles, and of Australian lady-beetles, *Cryptolaemus montrouzieri* Mulsant attacking exposed mealybugs, and *Rodolia* (*Vedalia*) *cardinalis* Mulsant attacking cottony cushion scale, may now be added that of a large wasp, *Larra americana* Saussure, a specific parasite of the changa, (or Puerto Rican mole-cricket, *Scapteriscus vicinus* Scudder).

The changa is not native to Puerto Rico, but occurs throughout most of tropical South America, and is presumably so destructively abundant in Puerto Rico, attacking tobacco, vegetable crops and even sugar-cane in sandy soils, because of the absence here of its natural enemies. Its parasite, *Larra americana*, occurs most conveniently for collection and shipment by airplane at Belem, Pará, Brazil. A successful method of shipping the live wasps, by including with them a screened cage of live parasitized mole-crickets, has been briefly reported,[1] as well as a more extended account of the entire project up to February, 1938.[2] Whether including live parasitized changas with each sending of the wasps is really the reason why the latter remain alive in captivity was not determined by later experiments, but out of 420 wasps sent thus from Belem in May and

1 SCIENCE, 87: 355, 1938.
2 *Jour. Agr. Univ. Puerto Rico*, 22: 193–218, 1938.

June of 1938, 373 arrived alive in Puerto Rico. Some of these wasps were released immediately, but others were used for oviposition on mole-crickets collected in Puerto Rico, and these, together with the parasitized changas which had accompanied the wasps, were released in Puerto Rico to the number of 550. Releases were made in a sandy region near Rio Piedras, and in a similar region near Isabela, in both of which places changas were abundant, and also the plants which the wasps frequent to obtain nectar.

At the end of the rainy season in Puerto Rico, in mid-January, 1939, *Larra* wasps were seen in considerable abundance both at Rio Piedras and at Isabela. These wasps could not possibly be any of those originally released, for the life of the insect is measured by weeks; thus they represent descendants of those released in May and June. Their presence indicates that *Larra* has successfully lived through the coldest and wettest as well as the hottest weather normally experienced in Puerto Rico, and may be considered as established at two localities here. How soon *Larra* will begin to spread to other parts of the island, where conditions are possibly somewhat less favorable, and how soon it will result in a marked decrease in changa injury, can not now be predicted, but at least its establishment in two widely separated regions marks one more step in the solution of the problem of control of the changa by natural means.

GEORGE N. WOLCOTT
AGRICULTURAL EXPERIMENT STATION,
UNIVERSITY OF PUERTO RICO,
RIO PIEDRAS

## OVUM CULTURE

IN certain press reports of a recent paper on meiosis in explanted human ovarian ova the statement has appeared that I plan to carry on this work to the extent of attempting to discover if human offspring can be produced by the methods we employ in ovum culture. This statement is incorrect. My work with human ova ended with these studies of maturation, and I have no intention whatsoever of continuing them.

GREGORY PINCUS
CLARK UNIVERSITY

## LECTURERS IN GEOLOGY AND GEOGRAPHY

AT the recent annual meeting of the Division of Geology and Geography of the National Research Council the suggestion was made that university departments in various parts of the country may be interested in knowing when distinguished foreign geologists and geographers are available for special lectures. The division chairman was requested to organize a sort of information bureau for this purpose. Every year some scientists in these fields visit this country. At the present time a number of such scientists are here as refugees from foreign countries.

After some exchange of information on the subject it may be possible to arrange lecture tours, planned cooperatively by neighboring universities and colleges in such a way as to reduce to a minimum the cost involved for each institution. As a first step in organizing the required information, those who know of men suitable and available for such lectures are requested to send to the undersigned the names and addresses of the men, together with pertinent data regarding their careers and publications. When sufficient information has been brought together, a means for its publication will be found.

The ability of each prospective lecturer to speak clear English is of course an important requisite. It is requested that this point be given particular attention in all information that is furnished.

The present college year is near its close. However, information furnished during the summer may make possible the institution of the plan early next fall.

CHESTER R. LONGWELL,
*Chairman, Division of Geology and Geography,*
*National Research Council,*
*2101 Constitution Ave., Washington, D. C.*

# SOCIETIES AND MEETINGS

## SIGMA PI SIGMA CONVENTION

THE fourth national convention of Sigma Pi Sigma, physics honor society, was held from April 6 to 8 at the Ohio State University. One hundred and thirty-two guests and delegates from twenty-eight chapters were registered. The convention program included inspection tours of research activities at the university and the Perkins Astronomical Observatory, scientific addresses and demonstration lectures, business sessions and social events. The presidential address by Dr. R. C. Colwell, of West Virginia University, on "Electromagnetic Waves and Radio Signals" described his own and other researches on ionizing layers in the atmosphere. Mr. Royal Weller, of the Ohio State University, presented a demonstration lecture of novel experiments in general physics. At the banquet the speakers were Dr. Alpheus W. Smith, head of the physics department at Ohio State, Dr. W. H. Bennett, director of research at the Electronic Research Corporation, Newark, Ohio, and Dr. H. W. Russell, director of the Battelle Memorial Institute, Columbus, Ohio. The main convention open meeting was addressed by Dr. Paul E. Klopsteg, president of the Central Scientific Company, following his reception into the society as an honorary member. His address on "Archery: A Physicists' Hobby" was illustrated by lantern slides

and an extensive exhibit of bows and arrows of both modern and ancient design. Dr. Klopsteg described the researches which he and others have made upon the scientific investigation of the physics of archery, which led to an explanation of the "paradox of archery" and the design of bows of incomparably better performance than those formerly used.

A panel discussion on the topic "How Shall the Physicist Get a Job?" was conducted by Dr. M. N. States, with Dr. W. P. Davey, of the Pennsylvania State College, and Dr. William E. Forsythe, of the Nela Park Research Laboratories, as principal speakers. At the Perkins Observatory of the Ohio State and Ohio Wesleyan Universities, the director, Dr. N. T. Bobrovnikoff, gave an illustrated address on "Astrophysics, a Borderland Science."

The convention authorized the expansion of the services of the placement board of the society and its establishment upon a permanent basis. This board will serve as an agency to bring to the attention of prospective employers of physicists the availability of certain members of the society and will function as a general clearing house for information regarding the placement of graduates in physics.

The report of the executive secretary to the convention indicated that the society has a total membership of 2,435 and an active chapter membership of 650. There are thirty-two active chapters. The convention authorized the establishment of a classification of "sustaining membership" among the alumni members of the society. The contributions of these members are to be kept in a separate fund and administered by a fellowship board to assist graduate-student members of the society to pursue further graduate work and research.

The executive secretary also reported that the society had just installed its thirty-second active chapter on April 4 at the Fort Hays Kansas State College, Hays, Kansas. The installing officers were Dr. Malcolm C. Hylan, of the University of Colorado, and Dr. R. A. Rogers, of Park College. At a general college assembly preceding the installation, Dr. Hylan gave an illustrated address on "A Dream Come True," in which he discussed some of the contemporary developments in the field of induced radioactivity. The charter group included thirty-one students and alumni. Dr. Harvey A. Zinszer is the head of the department of physics at Hays.

Officers elected at the close of the convention were: *President,* Dr. F. C. Blake, Ohio State University; *Vice-president,* Dr. Joyce C. Stearns, University of Denver; *Executive Secretary,* Dr. Marsh W. White, the Pennsylvania State College. Members of the Executive Council elected were: Dr. R. C. Colwell, West Virginia University; Dr. D. W. Cornelius, University of Chattanooga; Dr. W. P. Davey, Pennsylvania State College, and Dr. R. I. Allen, John B. Stetson University.

MARSH W. WHITE,
*Executive Secretary*

## THE KANSAS ACADEMY OF SCIENCE

THE seventy-first annual meeting of the Kansas Academy of Science was held at the University of Kansas, on March 30, 31 and April 1, 1939, under the leadership of Dr. Walter H. Schoewe as president. The opening lecture was given by Dr. Charles A. Shull, of the University of Chicago, who spoke on Thursday evening on the subject, "The Plant in Relationship to the Water System of Its Environment." This lecture was sponsored by the Kansas chapters of Phi Sigma, Sigma Xi and the Kansas Academy of Science.

Sectional programs opened on Friday morning and continued until 11 o'clock, when the first general business session was held. An interesting innovation in the program of the first business session was oneminute reports of the recipients of the 1938 research awards. These were followed by reports of officers, delegates to meetings and a lantern slide demonstration lecture on color photography by Oren Bingham. The slides were truly remarkable in their beauty, range of subjects and color values.

The second business and general session was held on Saturday at 8 A.M. President Schoewe gave the annual presidential address on the subject, "The Conservation of our Natural Areas." This is a subject in which Dr. Schoewe is greatly interested and is unusually well fitted to discuss. He stressed the difficulties which have arisen to making areas into national parks or national monuments and maintaining them as such.

Mrs. Otilla Reagan, who so graciously established the Albert B. Reagan Endowment in the Academy in memory of her distinguished husband, attended the academy sessions and spoke following the business meeting on "Reminiscences of our Indian Service." She recounted many interesting experiences and observations during their long period of work on Indian Reservations.

The Committee on Research Awards made the following grants for 1939–1940: To F. L. Carter, of Wilson, Kansas, award no. 3 of $32.50 from the Albert B. Reagan Memorial, for "A Study of the History of the Changes in the Mammal Population in Western Kansas"; to Claude W. Hibbard, of the University of Kansas, $25.00 for "Completion of a Study of the Upper Pliocene Fauna of Kansas, and Relation to the Blanco Fauna of Texas"; to Andrew Riegel, graduate student of Fort Hays Kansas State College, $25.00 for "A Study of the Variations in Growth of Blue Grama Grass"; to Charles Wolfson, graduate

student at the University of Kansas, $32.50 for "Investigations of Existence and Origin of Electrical Potential Differences in Single Cells"; and to A. P. Friesen, of Bethel College, Newton, Kansas, $35.00 for his study of the "Determination of Optical Properties of Liquid Metals and Alloys." The total awarded was $150.00, consisting of $75.00 from the American Association for the Advancement of Science, $42.50 from the academy treasury and $32.50 from the Reagan endowment.

The Kansas Weather-crops Seminar, Dr. J. H. Parker, president, and Dr. H. H. Laude, secretary, affiliated with the academy.

A series of lantern slides on the monument rock area in Gove County, Kansas, were shown as a part of the report of the committee on natural areas. George M. Robertson reported on the geology, F. W. Albertson on the flora, and L. D. Wooster reported on the fauna of this area, which it is hoped to have designated some day as a state park.

The reports of the sections are presented in Table 1.

TABLE 1

| Name of section | Chairman, 1939 | Attendance | Number of papers | Chairman for 1940 |
|---|---|---|---|---|
| 1. Botany | C. C. McDonald | 75 | 33 | M. W. Mayberry |
| 2. Chemistry | F. T. Owen | 60 | 12 | Harold P. Brown |
| 3. Geology | D. C. Schaffner | 50 | 19 | A. C. Carpenter |
| 4. Medical Science | Parke Woodard | 60 | 12 | none |
| 5. Physics | P. S. Albright | 80 | 15 | A. B. Cardwell |
| 6. Psychology | Jos. W. Nagge | 63 | 15 | W. H. Mikesell |
| 7. Biology Teachers | Gladys Beck | 40 | 7 | John Breukelman |
| 8. Zoology | E. H. Herrick | 60 | 37 | A. B. Leonard |
| 9. Kans. Entomological Society | L. C. Woodruff | 55 | 28 | R. T. Cotton |
| 10. Junior Academy of Science | Bob Akey, President<br>Dorothy Brownlee, Secretary | 250 | 12 | Gabe Sellers, Jr., President<br>Kenneth Hunt, Secretary |

The Junior Academy Committee, consisting of Miss Edith Beach, chairman, J. R. Wells and J. A. Brownlee, had an unusually successful year. Twenty-nine Junior Academy groups are now affiliated with the academy, of which 12 are new members and were specially inducted into the association with appropriate ceremony. Eleven clubs participated in the program. The Manhattan High School group was awarded first place because of their demonstrations and exhibit and were given possession of the Junior Academy cup for the year. Lawrence Junior High School was awarded second place. Jane Miller, of Lawrence, and Bob Hull, of Wichita, were awarded the honorary Junior memberships in the American Association for the Advancement of Science for the year.

The Kansas and Nebraska chapters of the American Association of University Professors again met in cooperation with the academy, under the chairmanship of Dr. D. A. Worcester. The attendance was 65, and there were four main addresses given. Professor Robert Conover was elected chairman for 1940.

On Friday evening, the regular banquet was held, with Dr. H. H. Hall, president-elect, as toastmaster. Chancellor E. H. Lindley gave an appropriate short address of welcome, emphasizing that science and scientists are less presumptuous now than formerly and that they now have their logical, but important, place in institutions of higher learning along with arts, literature and the humanities. Following the banquet occurred the unusually instructive and interesting illustrated lecture by Dr. Laurence McKinley Gould on "Explorations in the Antarctic."

The newly elected officers for 1939–1940 are: *President,* Dr. H. H. Hall, Kansas State Teachers College, Pittsburg; *President-Elect,* Dean E. O. Deere, Bethany College, Lindsborg; *Vice-President,* Dr. F. C. Gates, Kansas State College, Manhattan; *Secretary,* Dr. Roger C. Smith, Kansas State College; *Treasurer,* Dr. H. A. Zinszer, Ft. Hays Kansas State College, Hays; *Executive Council*—Dr. W. H. Schoewe, the retiring president, Lawrence; Dr. L. D. Bushnell, Kansas State College, Manhattan, and Dr. R. H. Wheeler, University of Kansas, Lawrence. *Associate Editors:* Dr. R. E. Mohler, McPherson College, and Dr. A. B. Cardwell, Kansas State College, Manhattan, both serving until 1942.

Three hundred and thirty-five persons registered for the meeting, which is the largest registration ever recorded for an annual meeting. One hundred twenty-five new members joined the academy during the year. The present membership totals 686. The academy lost 10 members by death during the year.

The following chairmen of committees were appointed by President-Elect Hall for 1939–40: The Committee on Conservation and Ecology, W. H. Schoewe; Research, L. D. Wooster; Coordination of Science Groups, W. J. Baumgartner; Handbooks, R. J. Barnett; Membership, Roger C. Smith; Necrology, Roy Rankin; New Sections, F. C. Gates; Junior Academy, J. A. Brownlee; Editorial Trends, J. A. Glaze; Science Teaching, J. A. Trent; Coordinating Finance, H. A. Zinszer; Publication Fund, F. W. Albertson; Endowments and Investments, H. A. Zinszer; State Aid, W. J. Baumgartner, and Nominating, W. H. Matthews.

The academy will meet at Wichita in 1940, and at Manhattan in 1941.

Roger C. Smith,
*Secretary*

Kansas State College,
Manhattan

# SPECIAL ARTICLES

## A COMPARISON OF WATER CULTURE AND SOIL AS MEDIA FOR CROP PRODUCTION

IN recent years, great interest has been aroused in the possibilities of using a water-culture medium, as an alternative to soil, for purposes of crop production. The idea of making commercial use of the water-culture method, heretofore employed for over three quarters of a century solely for scientific studies, was conceived some time ago by W. F. Gericke, who devised a special technique for growing plants in large tanks filled with nutrient solution.[1, 2]

This development was soon given great publicity in the popular press and stimulated wide discussion of the possible social and economic implications of certain proposals for dispensing with the soil as a medium for growing many crops. Such discussion has frequently been based on the following claims: (1) The inherent productive capacity of a given surface of nutrient solution far surpasses that of an equivalent surface of even very fertile soil; either because individual plant yields are higher or because plants can be grown more closely spaced in nutrient solutions than in soil; (2) heating the nutrient solution results in large increases in yields of crops; (3) plants can be grown in nutrient solutions with greater water economy than in soil; (4) food produced by the water-culture method has a higher dietetic value (minerals and vitamins) than that produced in soil; (5) plants grown in nutrient solutions are, in contrast with those grown in soil, free from attack of insects and diseases.

At the suggestion of the director of the California Agricultural Experiment Station, we have undertaken to gain information which would bear directly on the claims listed above, by comparing, under controlled greenhouse conditions, a fertile soil with a favorable nutrient solution, as media for crop production. A full discussion of the results will be published elsewhere, but it is desired to present at this time some of the results and conclusions which may be of general interest.

Since much of the current discussion of the water-culture method is based on work with the tomato, it was adopted as a test plant for this investigation. Tomato plants were grown in a Berkeley greenhouse, in soil and nutrient solution, side by side, with the same spacing and cultural treatment for plants grown in the two media. This arrangement was considered essential to any attempt to compare yields attainable by the two methods. In most popular discussions of the subject, yields of fruit harvested on a small unit of surface, from tomato plants grown in the protection of a greenhouse, for a twelve-months period, have been compared with average field yields under all types of soil and climatic conditions, computed on the basis of large acreages. Such comparisons may be very misleading.

The soil beds occupied the same surface as the tanks of nutrient solution (25 square feet) and consisted of an open-bottom box filled with soil to the depth of two feet. The soil, secured from a commercial greenhouse, had been used successfully in the production of tomatoes. It was autoclaved for 6 to 7 hours prior to use and fertilized with manure, potassium and phosphorus, with the addition of gypsum, in a manner corresponding to the usual fertilization treatment given to that soil under commercial conditions. The nutrient solution, including microelements (solutions A4 and B7), used in the water-culture tanks, has been previously described.[3]

The spacing of plants, the porous bed used in all water-culture tanks, and the heating arrangement used in some soil and water cultures were similar to those described by Gericke and Tavernetti.[2]

Two crops were grown in the course of one calendar year: A fall-winter crop from August to January and a spring-summer crop fom February to August. In the latter period, an aerated unheated nutrient solution and a heated bed of pure sand, 2 feet deep, irrigated daily with nutrient solution, were included in the experiment. The temperature in the heated cultures was maintained around 70° F. in the fall-winter period, and around 75° F. in the spring-summer period. The temperature in the unheated soil and solution varied from 57° to 68° F., depending on the air temperatures.

All plants were staked and trained to single stems, and were allowed to extend to the full height of the greenhouse. Records of individual plant yields were kept only during the spring-summer period (Table II). Since fruit was borne over the entire length of vines, the highest yields were obtained from the tallest

TABLE I

YIELD OF TOMATO* PLANTS GROWN FOR A SIX MONTHS' PERIOD FROM AUGUST TO JANUARY IN SOIL AND NUTRIENT SOLUTION

(20 plants to 25 square feet of surface)

| Treatment | Average yield per plant in pounds |
|---|---|
| Soil heated | 6.0 |
| Solution heated | 5.7 |
| Soil unheated | 6.7 |
| Solution unheated | 5.5 |

* Variety Crackerjack (Earliana).

1 W. F. Gericke, *Am. Jour. Bot.*, 16: 862, 1929.

2 W. F. Gericke and J. R. Tavernetti, *Agr. Engineering*, 17: 141–143, 1936.

3 D. I. Arnon, *Am. Jour. Bot.*, 25: 322–325, 1938.

plants and lower yields from those which could extend only to the lower portion of the sloping greenhouse roof. The highest yields of individual plants from soil and water-culture are given in Table II to indicate the potentialities for fruit production of both media, with relatively unrestricted vertical extension of vines.

TABLE II

YIELD OF TOMATO PLANTS* GROWN FOR A SIX MONTHS' PERIOD FROM FEBRUARY TO AUGUST IN SOIL, SAND AND NUTRIENT SOLUTION

(20 plants to 25 square feet of surface)

| Treatment | Average yield per plant in pounds | Highest yield of individual plant in pounds |
|---|---|---|
| Soil heated | 14.2 | 28.1 |
| Solution heated | 17.0 | 24.1 |
| Soil unheated | 13.9 | 24.1 |
| Solution unheated | 15.7 | 20.2 |
| Solution unheated, aerated | 21.1 | 28.0 |
| Sand heated | 21.6 | 32.4 |

* Variety Lloyd Forcing. We are indebted to Dr. W. A. Huelsen, of the Illinois Agricultural Experiment Station, for furnishing the seed.

The yields, on the basis of comparable season and time period, obtained in our experiments with the water-culture method previously described[2,4] were higher than any heretofore reported,[2,4] but considering the variability of cultures, these yields can not be regarded as markedly different from those obtained in soil.[5] The average yields, as well as the highest yields of individual plants, from soil and water cultures do not justify a conclusion that the potential crop yield is higher in a favorable nutrient solution than in a fertile soil. Nor was any evidence found in support of the contention that higher yields per unit of surface can be expected from the water-culture technique as a result of closer spacing of plants than is possible in soil. As already pointed out, the same dense spacing was maintained in the soil beds and in the water-culture tanks and yet no difficulty was experienced in either medium in supplying enough water and nutrients to the plants. The indications were that even under the favorable light conditions prevalent at Berkeley, California, the light factor would determine the most profitable spacing of plants in either soil or nutrient solution, assuming a favorable root environment in both.

Heating the nutrient solution produced no great effect at the two periods of the year on the yield of fruit (Tables I and II). The greenhouse was not heated except on a few occasions to prevent temperatures from falling below 50–55° F. The average Berkeley greenhouse air temperatures during most of the year were sufficiently high to maintain in the unheated cultures a nutrient solution temperature around 65° F., which was adequate for growth. It appears, therefore, that if air temperatures are favorable, the solution temperature will take care of itself.

A marked increase of yield of fruit from unheated nutrient solution resulted from continuous forced aeration. The beneficial effect of improved aeration was also reflected in the growth and yield of plants in sand culture (Table II). There is no reason to believe, however, that comparable yields could not be produced in a soil, which would combine the conditions of optimum aeration, associated with light texture (lighter than that of the soil used in this investigation), with a fully adequate supplying power for nutrients and water. These results suggest, incidentally, that under many climatic conditions aeration of solutions may hold greater promise of increasing yields in commercial water-culture practice than heating the solution.

In the spring-summer experiment records were kept of the amounts of water supplied to the soil and solution cultures. The level of nutrient solution in the tanks was maintained within several inches from the top of the tank, while the usual commercial practice was followed in watering the soil. The experimental data (Table III) indicate that more water was required to produce a unit weight of fruit under water-culture conditions than under soil conditions, although the significance of the difference in water consumption can not be evaluated on the basis of evidence now available.

TABLE III

UTILIZATION OF WATER IN THE PRODUCTION OF TOMATO FRUIT IN SOIL AND NUTRIENT SOLUTIONS

| Treatment | Gallons of water used to produce 100 pounds of fruit |
|---|---|
| Soil heated | 214 |
| Solution heated | 276 |
| Soil unheated | 222 |
| Solution unheated | 257 |

As a part of this investigation, studies of chemical composition and general quality have been made on tomatoes of several varieties grown in the greenhouse in fertile soil, sand and water culture media under the same climatic conditions. No significant difference has been found in the calcium, phosphorus, magnesium, potassium, nitrogen and sulfur content of fruit developed on plants grown in the several media. Neither could any significant difference be found in content of carotene (provitamin A), and vitamin C. Tomatoes harvested from the soil and water-culture could not be consistently distinguished in a test of flavor and general quality.[6]

[4] W. F. Gericke, *Nature*, 141: 536–540, 1938.

[5] Recently data have also become available on yield of potatoes grown in a bed of peat soil in Berkeley. This yield was as large as any heretofore reported as obtained by the water-culture method.

[6] The quality tests were conducted by Dr. Margaret Lee Maxwell, of the Division of Home Economics, and the carotene determinations were made by Dr. Gordon Mackinney, of the Division of Fruit Products, College of Agriculture.

Contrary to some statements, plants grown by the water culture method are not protected against diseases or insects attacking the aerial parts of plants. While the risk of strictly soil-borne disease can be ruled out, recent observations suggest that diseases peculiar to water culture may sometimes attack plants grown in nutrient solutions.

The results of our experiments confirm earlier views that the possibility exists of producing crops on a large scale by the water-culture method. The fact that yields and general quality of plant products are at least equal to those produced under extremely favorable soil conditions (admittedly not generally found) is considered of great interest, but no support was found for the assumption that the potentialities for crop production of a favorable nutrient solution medium far exceed those of a very fertile soil.

A sober appraisal of the commercial possibilities of the water-culture method should be based not on the expectation of fabulous yields, far in excess of any obtainable in soil, or unusual dietary qualities of plant products, but rather on the knowledge that under competent supervision very good crops could be produced in localities favored in climate and water supply, but where good soil is not available or when it is found too expensive to maintain highly favorable soil conditions. Also a water-culture medium when expertly supervised should be subject to more exact control than a soil medium. Other investigators have developed large-scale techniques for growing crops in inert solid media, such as sand and gravel.[7,8]

It must be clearly recognized that the application of the water-culture method for crop production will be limited primarily by economic considerations. What crops could be grown profitably by this method would depend on the value of the crop in the market served in relation to cost of production, which would include a large outlay for tanks and other equipment and materials, as well as special costs of supervision and operation. An important distinction must be made between field and greenhouse operations. It seems highly improbable, in view of the present cost of a commercial water-culture installation and its operation, that crops grown by this method could compete with cheap field-grown crops.[9] In greenhouses specializing in high-priced, out-of-season crops the method appears to have commercial possibilities. The expense of growing greenhouse crops in soil, including cost of equipment for sterilizing soils, may frequently stand comparison with the cost of growing crops by the water-culture method.

However, before any one undertakes to grow plants by the water-culture method, even in greenhouses, he should give the most careful consideration to the economic factors involved and to the need for expert guidance, in the absence of which commercial success is unlikely. The practical experience which many growers have acquired in growing plants in soil may prove of little avail in solving some unfamiliar problems of water-culture technique. It is suggested that those who contemplate installation of the water-culture method for commercial purposes make a preliminary test with a few tanks, to learn some of the requirements of the process.

The suggestion that important amounts of food could be produced economically in small-scale installations for home use has no sound basis, because of high costs of the installations and technical requirements for the successful use of the method.

The continued importance of the use of water-culture technique, as one important method of scientific experimentation in investigations of problems of plant nutrition, needs to be stressed. The development of large-scale water-culture techniques enhances the usefulness of the water-culture method as an experimental tool, by widening its scope of application to problems which involve growing plants to maturity on a large scale and under controlled conditions of nutrition.

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[7] H. M. Biekart and C. H. Connors, *New Jersey Agr. Exp. Sta. Bul.* 588, 1935.

[8] R. B. Withrow and J. P. Biebel, *Purdue Agr. Exp. Sta. Cir.* 232, 1937.

[9] Recently, popular journals have discussed a project for growing vegetables in tanks of nutrient solution, on Wake Island, in Mid-Pacific, to supply fresh vegetables (which constitute only a small proportion of the total food requirements) for the inhabitants of the island and for passengers of the Clipper airships. This, however, is a special case, and there is no reason to assume that it has any general agricultural significance.

## THE CHORIO-ALLANTOIC MEMBRANE OF THE DEVELOPING CHICK AS A MEDIUM FOR THE CULTIVATION AND HISTOPATHOLOGIC STUDY OF PATHOGENIC FUNGI

ALTHOUGH the chorio-allantoic membrane of the developing chick has been used by numerous investigators as a medium for the cultivation and study of many bacteria, viruses, Rickettsiae and recently of a spirochete,[1] it has not been used extensively (as far as could be determined) for the study of fungi. Goodpasture[2] mentioned these micro-organisms in his Leo Loeb Lecture at the Washington University School of Medicine, on March 24, 1938, and in personal correspondence stated, "we have never made any consistent investigation of fungus infection in this host" (embryo chick). The purpose of this paper is to report briefly

[1] G. Morrow, J. T. Syverton, W. W. Stiles and G. P. Berry, SCIENCE, 88: 384, 1938.

[2] E. W. Goodpasture, *Am. Jour. Hyg.*, 28: 111, 1938.

the results of the successful inoculation of the chorio-allantois with fungi.

During the year of March, 1938, to 1939, work was started at Barnard Hospital to determine the possible virus etiology of a number of skin diseases, the causes of which are obscure. We have been equipped with the apparatus to carry on the technique of chick egg inoculation as practised in Goodpasture's laboratory and as elaborated by Goodpasture and Buddingh.[3] Dr. Floyd S. Markham, who has been carrying on the virus work, assisted in the inoculation of the chick membranes with fungi.

A wide variety of pathogenic fungi have been used, representing the causative agents of diseases which affect: (1) the superficial layer of the skin; (2) mucous membranes; (3) dermis and subcutaneous layers; (4) internal viscera. These organisms are known to produce pityriasis, superficial desquamations, localized granulomata, deep-seated ulcerative lesions, mucous membrane plaques; lymph stream invasion with dermic and subsequent epidermic involvement and visceral or generalized diseases. These microbes produce the following diseases: seborrheic dermatitis, tinea versicolor, endomycosis, geotrichosis, moniliasis, blastomycosis, coccidioidal granuloma, sporotrichosis, maduromycosis, trichophytosis, epidermophytosis, microsporosis, favus, cryptococcosis, paracoccidioidal granuloma, chromomycosis and actinomycosis.

The fertilized eggs used were 12 to 14 days old. Inoculations from cultures of the fungi were made directly on the chorio-allantoic membrane. The embryo lived from 4 to 11 days after inoculation, depending on the type of organism used. Macroscopically the diseases manifested themselves as thickened or thin, white, grayish or grayish-brown, confluent or discrete plaques on the membrane, depending again on the variety of fungus.

The infected membranes were fixed in Zenker's, embedded in paraffin, sectioned and studied. Histopathologically, the reaction of the tissue manifested itself in the form of nodules, ulcers, superficial growths and hyperplastic lesions, which were comparable in most instances to those seen in human infections. Further microscopic examination showed an increased activity in the membranes, as was evidenced by the intense infiltration, particularly with the invasive type of organism, of ectodermal cells, blood cells, fibroblasts, monocytes, accompanied in most cases by inflammatory changes in the mesoderm and marked edema at the sites of fungus growth. The thickening of the membrane in some cases was due to the cellular infiltrate, in others where the organism is known to produce granulomatous lesions, to the mat of mycelial elements of the fungus, but in most cases to the combination of both. Those membranes parasitized by *Monilia albicans,* in addition to the marked proliferation and hypertrophy of the ectoderm, showed, in the mesoderm, pearls of growth which correspond in human tissue to an increased hyperkeratinization. A degree of tissue specificity was also demonstrated in that fungi affecting mucous membranes and the superficial layer of the skin particularly involved the ectoderm, whereas those found affecting the dermis, subcutaneous layers and internal viscera seemed to affect in addition the entoderm and mesoderm. Intra-amniotic, intra-cerebral and body injections will be carried on to determine absolute specificity of tissues in the chick embryo to the various fungi.

The fungi stain very easily in section with methylene blue and eosine. In most cases the organisms revert to the forms seen in human lesions—their parasitic role. This reversion in morphology is complete with the yeast-like organisms in approximately 6 days, whereas with some filamentous forms it begins on the fifth day and is complete on the tenth or eleventh day.

In summary, it can be said, therefore, that the chorio-allantoic membrane of the developing chick can be successfully inoculated with pathogenic fungi. The organisms produce fatal mycoses with most microbes which in tissue response simulate closely human lesions, showing a degree of specificity as found in infection in man. This method, as contrasted with the use of standard laboratory animals, is much less expensive and, more significant than that, reduces the time elements from weeks or months to days. The inability to find suitable experimental animals or human volunteers enhances the value of the use of the chorio-allantois for fungous inoculations.

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[3] E. W. Goodpasture and G. J. Buddingh, *Am. Jour. Hyg.*, 21: 319, 1935.

## THE TRANSMISSION OF LYMPHOCYTIC CHORIOMENINGITIS BY MOSQUITOES

ONE year ago a highly virulent spontaneous infection occurred among rhesus monkeys that were being used in this laboratory for the study of experimental malaria. The severity of the infection was such that eleven monkeys died in a week. The infection was characterized by dependent edema, serosanguineous nasal discharge, marked prostration and extremely rapid course. At death the outstanding gross abnormalities were partial consolidation of the lungs and an abundant collection of straw-colored fluid in the serous cavities. The causative agent of the epizootic was identified by Dr. Thomas Francis, Jr., as being the virus of lymphocytic choriomeningitis. Under normal conditions the mode of transmission of this disease, either in man or animals, is unknown, but since the

virus was found to be present in high concentration in the circulating blood of some experimental animals, the possibility of an insect vector was considered. Experiments completed have demonstrated the ability of *Aedes aegypti* mosquitoes to transmit the disease to guinea pigs by bite.

In the initial experiment a guinea pig was inoculated subcutaneously with 1.0 cc of a 1–10 dilution of frozen and desiccated blood from one of the monkeys which had died 6 months previously. On the seventh day following inoculation, when the guinea pig was obviously ill, a lot of normal *Aedes aegypti* was allowed to feed upon it. Five days later seven of these mosquitoes were first allowed to bite a normal guinea pig, then were ground finely in a mortar with normal saline and injected into another normal guinea pig. The guinea pig which received the injection of killed mosquitoes died on the seventh day, and the one which was bitten by the same insects died on the eighth day. Before death another lot of normal *Aedes aegypti* was allowed to feed upon the latter animal. These mosquitoes also produced a fatal infection when six days later fifteen of the insects were permitted to bite a normal guinea pig, thus establishing two serial consecutive guinea pig-mosquito-guinea pig passages.

Other experiments have shown that the mosquitoes are capable of transmitting the virus as early as the fourth day and at least as late as the fifteenth day after feeding on an infected animal. Death has occurred between the eighth and eighteenth day following the bite of infected mosquitoes, while duplicate guinea pigs which were inoculated with an emulsion of the same mosquitoes usually died twenty-four to forty-eight hours earlier. In one experiment the bite of sixteen mosquitoes caused death on the eleventh day, while the bite of four mosquitoes from the same lot produced no obvious signs of illness. However, the surviving animal was later shown to be immune when inoculated with a large dose of known living virus. The study is being extended to include other hosts and vectors.

The virus of lymphocytic choriomeningitis in guinea pigs dying following the bite of infected mosquitoes was identified by means of a specific immunity test. The virus was neutralized by known immune guinea pig and immune monkey serum. The latter was from a monkey which survived the epizootic mentioned above and was found by Dr. J. E. Smadel, of the Rockefeller Institute, to contain both complement-fixing and neutralizing antibodies against a known strain of lymphocytic choriomeningitis virus.

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## INCREASED GLYCURONATE EXCRETION FOLLOWING ADMINISTRATION OF SULFAPYRIDINE[1]

IN the course of the isolation of urinary excretion products of sulfapyridine,[2] a urine concentrate containing a diazotizable substance in concentrations considerably above the solubility of sulfapyridine or its acetyl derivative was obtained. This suggested, among other things, that the drug might be excreted in part as a sulfate or a glycuronate. Concurrent with isolation studies, we have followed the glycuronate[3] excretion in two normal males on a carefully controlled diet after the administration of a single dose of five (5) grams of sulfapyridine. A pneumonia patient was similarly studied. In each case, the glycuronate output was markedly increased during the first twenty-four hours and fell to normal within two to four days. The glycuronate concentrations paralleled the urine levels of sulfapyridine.

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[2] H. D. Ratish, J. G. M. Bullowa, J. B. Ames and J. V. Scudi, *Jour. Biol. Chem.*, 128: 279, 1939.

[3] G. B. Maughan, K. A. Evelyn and J. S. L. Browne, *ibid.*, 126: 567, 1938.

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